

Visual MODFLOW Premium with MODFLOW SURFACT

A Step-by-Step Tutorial for the MODFLOW-SURFACT Trial Version

Airport-MS-5

Time(day): 0.0

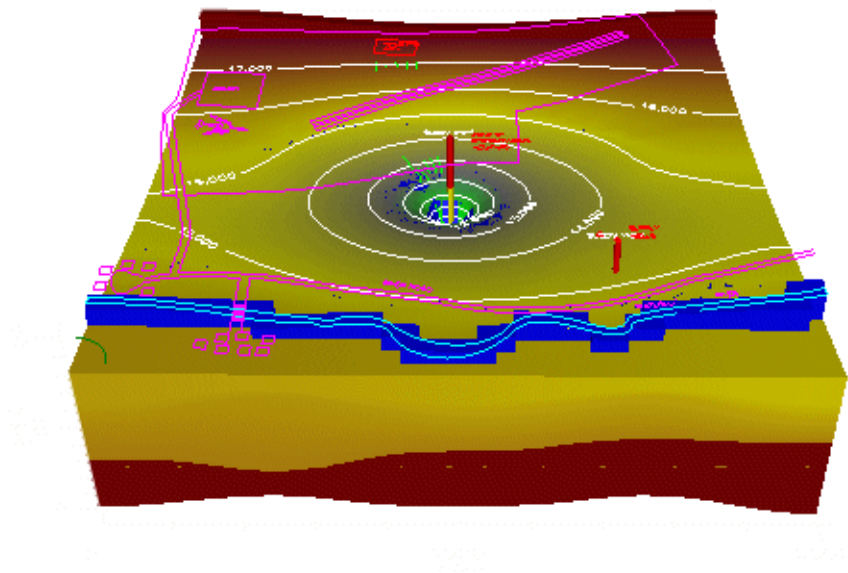


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Introduction

This document contains a step-by-step tutorial to illustrate the capabilities of the MODFLOW-SURFACT Flow Engine. This tutorial will guide you through the steps required to:

- Modify and Run a flow simulation using the MODFLOW-2000 Flow Engine, and inspect the output
- Modify and Run the same simulation using the MODFLOW-SURFACT Flow Engine, and compare the output to the MODFLOW-2000 simulation

NOTE: You must have Visual MODFLOW Standard or higher to be able to use this tutorial.

NOTE: Some features described in this tutorial are only available in Pro or Premium versions.

This tutorial assumes that you are already familiar with the Visual MODFLOW interface, and with the process of building a groundwater model. If you are not familiar with Visual MODFLOW, it is recommended that you work through the Visual MODFLOW demonstration tutorial first.

Benefits of MODFLOW-SURFACT

The key benefits of MODFLOW-SURFACT for flow simulations are highlighted below:

- Handles complete desaturation and resaturation of grid cells
- Capable of modeling the movement of water through the Vadose Zone
- Accurate delineation and tracking of water table position, taking into account flow in the unsaturated zone, delayed yield, and vertical flow components
- Automatic and correct redistribution of the total flow rate of a well screened through multiple model layers when the upper cell(s) are pumped dry
- Accommodation of well-bore storage, and overpumped wells
- Prevents water table buildup beyond a specified recharge-ponding elevation
- Handling of seepage face boundary conditions
- Adaptive time-stepping schemes automatically adjust time-step size to the non-linearities of the system, to optimize the solution stability
- Robust and efficient Pre-conditioned Conjugate Gradient matrix solver
- Capability of modeling unsaturated water or air movement
- Enhanced Newton-Raphson linearization option increases robustness for unconfined and/or unsaturated flow conditions

MODFLOW-SURFACT Interface in Visual MODFLOW

Currently, Visual MODFLOW supports a graphical user interface for the Flow component of MODFLOW-SURFACT. Transport simulations are not supported when using the MODFLOW-SURFACT Flow Engine.

Limitations of the MODFLOW-SURFACT Trial Version

The Trial version of the MODFLOW-SURFACT Flow Engine is restricted to:

- A model size of 50 rows by 50 columns by 5 layers
- A maximum of 5 stress periods and 50 time steps

The fully licensed version of MODFLOW-SURFACT is capable of working with the normal (default) grid size of Visual MODFLOW models, and with any custom grid developed for Visual MODFLOW by Waterloo Hydrogeologic

How to Use this Tutorial

This tutorial is divided into two modules, and each module contains a number of sections. Each section is written in an easy-to-use step-wise format. The modules are arranged as follows.

Module 1 - Running MODFLOW-2000 and Output Visualization

Module 2 - Running MODFLOW-SURFACT and Output Visualization

Terms and Notations

For the purposes of this tutorial, the following terms and notations will be used:

Type:- type in the given word or value

Select:- click the left mouse button where indicated

↔ - press the **<Tab>** key

↵ - press the **<Enter>** key

☞ - **Click** the left mouse button where indicated


☞☞ - double-click the left mouse button where indicated

[...] - denotes a button to click on, either in a window, or in the menu bars.

The **bold faced type** indicates menu or window items to click on, or values to type in.

Getting Started

To start this tutorial:

☞☞  (the Visual MODFLOW program icon) to start the Visual MODFLOW program

☞ **File>Open** from the Main Menu

Browse to the location of the tutorial files. From this folder, select the Airport-Surfact.vmf file, and

☞ **[Open]**

The Airport-Surfact model is already built and ready to run.

Module 1: Running the Simulation with MODFLOW-2000

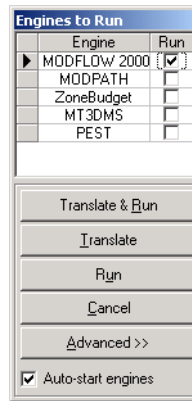
Module 1 guides you through the run of a simulation using MODFLOW-2000.

☞ **[Run]** from the Main Menu

Running the Simulation

☞ **[Run]** from the Top Menu bar

An **Engines to Run** dialog box will appear listing the available Numeric Engines (as shown in the figure below).



In the **Engines to Run** dialog, select the following options:

- ☞ ☒ **MODFLOW-2000**
- ☞ **[Translate & Run]**

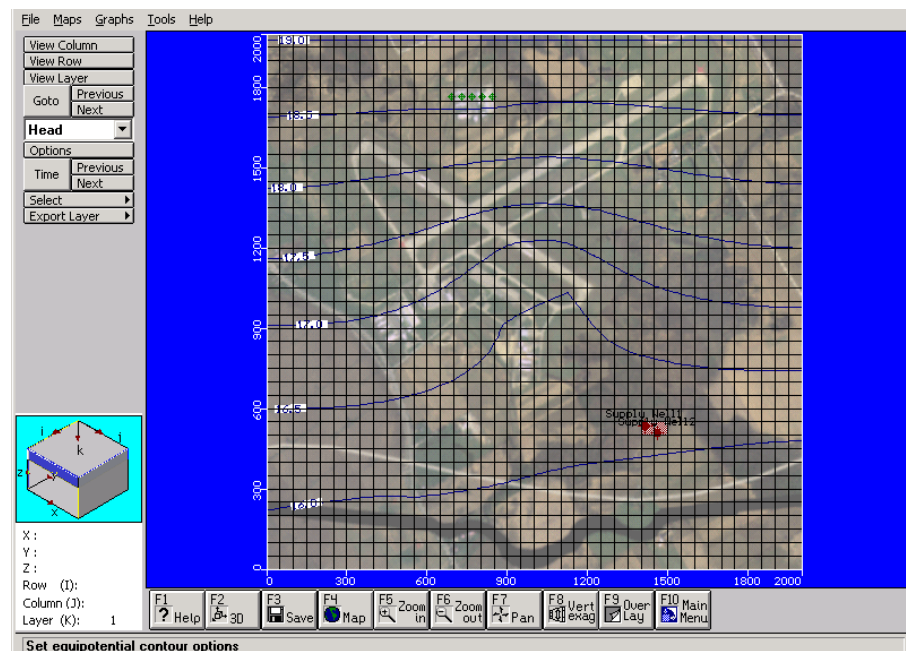
Visual MODFLOW will then **Translate** the Visual MODFLOW data set into the standard data input files required for the selected Numeric Engines, and then **Run** the simulations in a separate window labelled **VMEngines**.

Output Visualization

Once the model has converged, you may **[Close]** the **VMEngines** window.

- ☞ **Output** from the top menu bar of the **Main Menu**

Upon entering the **Output** section, Visual MODFLOW will automatically load the available Output files for Head (.HDS) for all output times. Once these data files are loaded, the **Output** screen will appear.



Displaying a Color Map of Heads

☞ **[Options]** button from the left-hand tool bar

A **C(0) - Head Equipotentials** contour options window will appear.

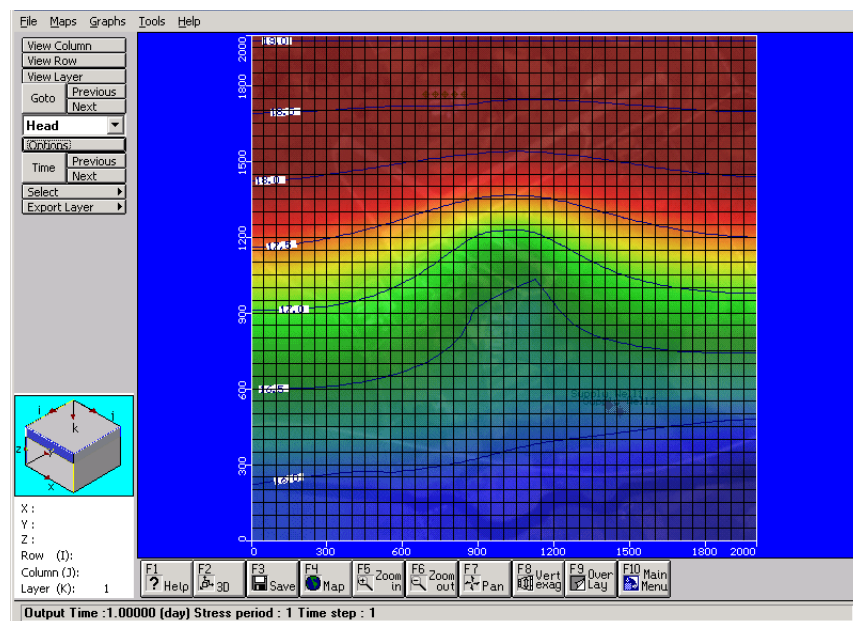
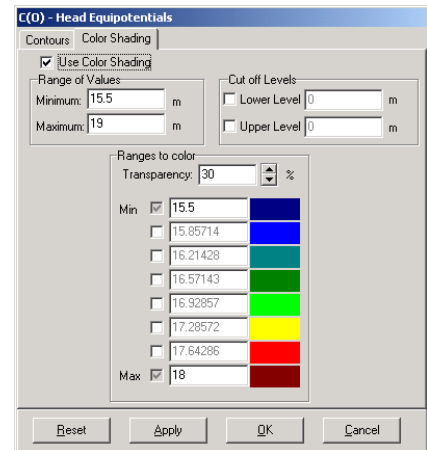
Click on the **[Color Shading]** tab.

The contour options dialog box should appear as shown on the right.

☞ ☒ **Use Color Shading**

☞ **[OK]** to accept these settings

A color map of the head equipotentials for the top layer of the model will be plotted according to the default color scale selected. Note that the color map is translucent in order to show the underlying model features.



Before you continue with this exercise, turn-off the color shading option to avoid the screen refresh times required to redraw the colormap.

☞ **[Options]** from the left toolbar

Click on the **[Color Shading]** tab.

☞ Remove the checkmark ✓ from the checkbox ☐ beside **Use Color Shading**

☞ **[OK]**

☞ **[F10 Main Menu]** button, and then **[Input]** from the top menu bar of the **Main Menu**

You will be transferred back to the Visual MODFLOW **Input** section where you can modify the model input.

Modifying Pumping Wells

Now that we have established a baseline for the simulation, we will modify the pumping wells to show how dry cells create model convergence problems for MODFLOW-2000.

- ☞ **Wells/Pumping Wells** from the top menu bar
- ☞ **[Edit Well]** from the left toolbar.

Move the cursor to the Supply Well2 (located in the lower-right) and left-click to edit the well.

An **Edit Well** window will appear. Supply Well2 is the second row in the well table (indicated in the figure below). In this row, remove the checkmark ✓ from the **Active** column to deactivate this pumping well.

Now select Supply Well1 from the well table by placing your cursor in the first row of the well table.

To change the **Screened Intervals**:

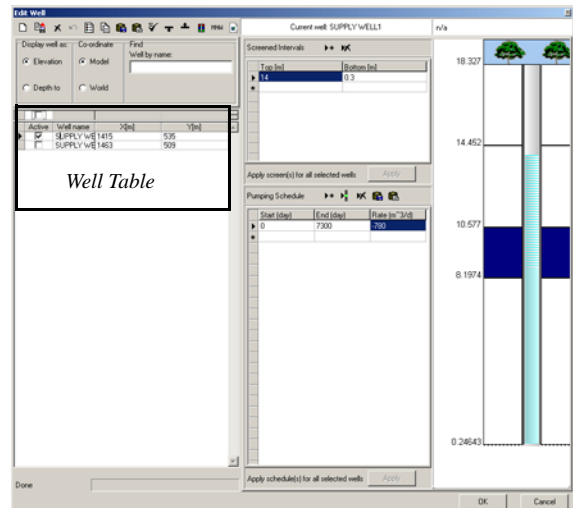
Click in the column labelled **Screen Top** and enter the following values:

Screen Top (m):14.0 ⇔

Screen Bottom (m):0.3 ⇔

Change the pumping **Rate (m³/day)** to **-780**,

- ☞ **[OK]** to accept these changes
- ☞ **[F10 Main Menu]**, and then click **[Yes]** to save your changes and return to the **Main Menu**.



Running the Simulation

To continue with the run options:

- ☞ **[Run]** from the **Main Menu** options
- ☞ **[Run]** from the Top Menu bar

In the **Engines to Run** dialog, select the following options.

- ☞ ☒ **MODFLOW-2000**
- ☞ **[Translate & Run]**

Visual MODFLOW will then **Translate** the Visual MODFLOW data set and **Run** the simulation.

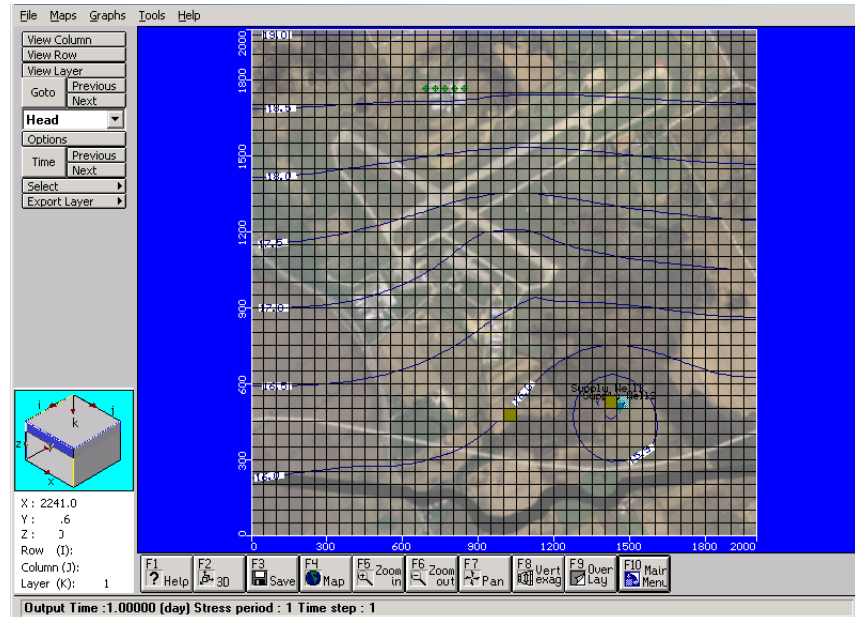
Output Visualization

Once the model has converged, you may **[Close]** the **VMEngines** window.

- ☞ **[Output]** from the top menu bar of the **Main Menu**

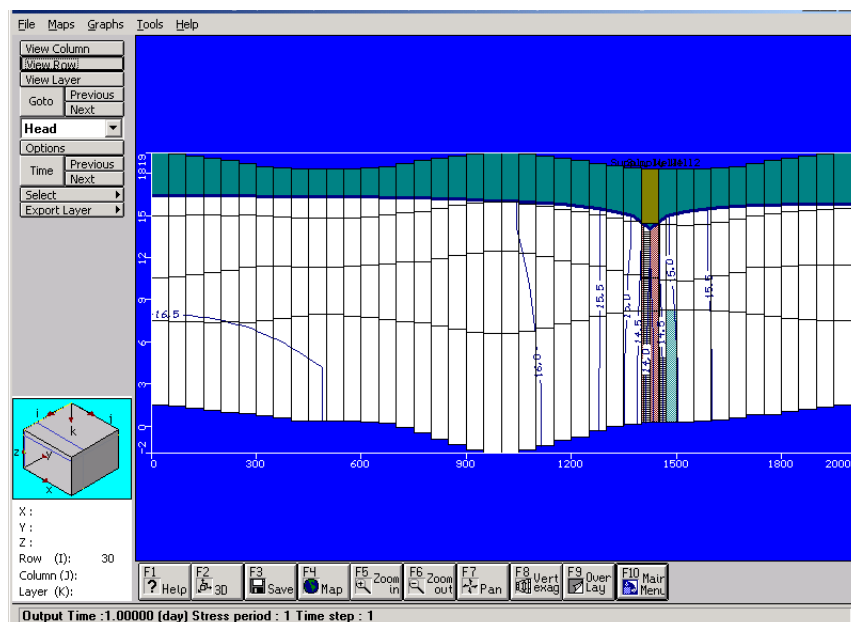
You will be transferred to the Visual MODFLOW **Output** section where you will view the new simulation results. This section provides instructions on displaying the de-saturated conditions (i.e. dry cells).

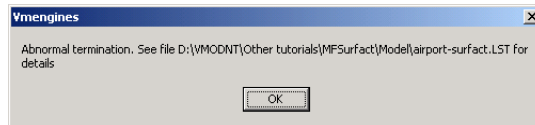
Upon entering the **Output** section, Visual MODFLOW will automatically load the available Output files for Heads (.HDS) and the **Output** screen will appear as shown below:



☞ **[View Row]** from side menu bar, and then move your cursor onto the model region.

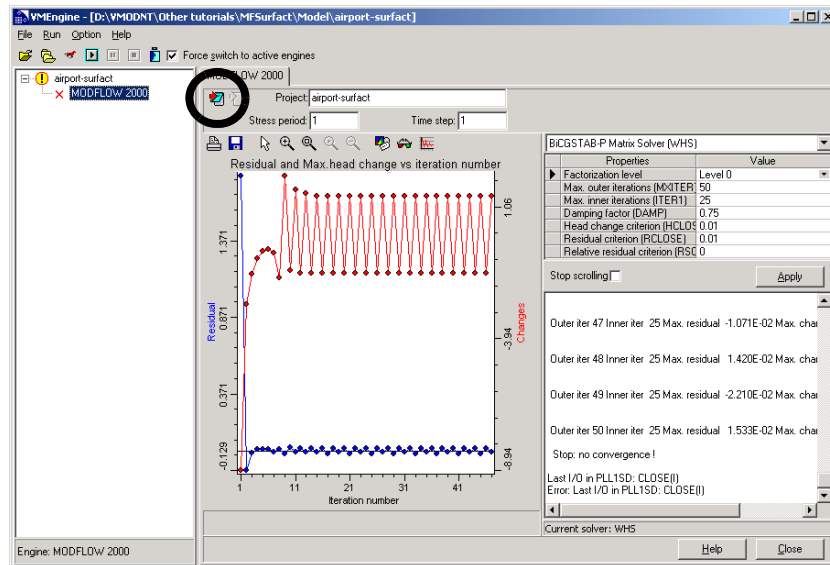
Click on a row to show the cross-section with the cone of depression around the pumping well, and dry cells. The display should look similar to the following figure (row 30).





☞ **[OK]** to close the dialog.

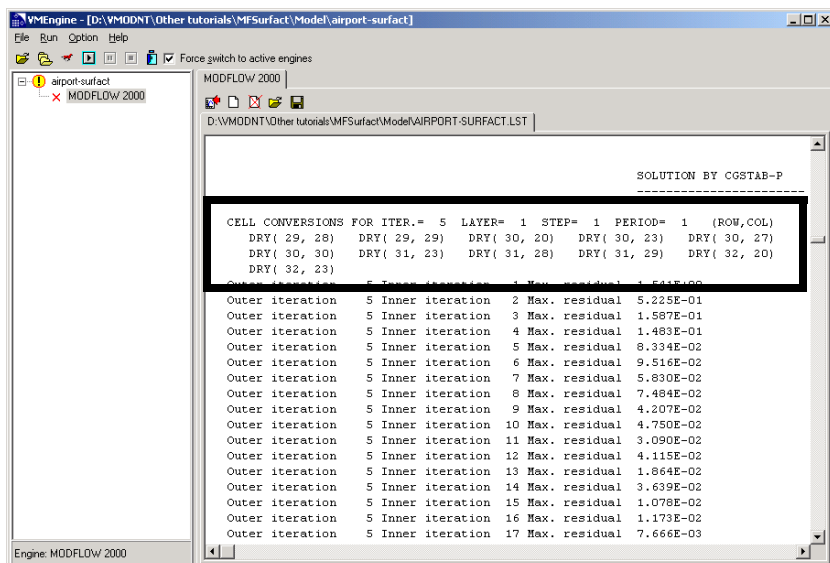
Expand the solver iteration window so you can see the **VMEngine** window as shown below.



Note that the maximum number of outer iterations (50) has been reached without satisfying the head change criterion, and a “Stop: no convergence!” message is displayed at the end.

☞ **(Show files)** icon, and an **Open** window will appear. In this window, select **AIRPORT-SURFACT.LST** and click **Open** to view the Listing file.

Scroll down to examine the “Cell conversions for iter.=” entries (starting approximately 1/4 through the file), when MODFLOW converts a cell from wet to dry or vice versa. You can see that some cells in layer 1, rows 29-32 are dry, which is preventing the model convergence.



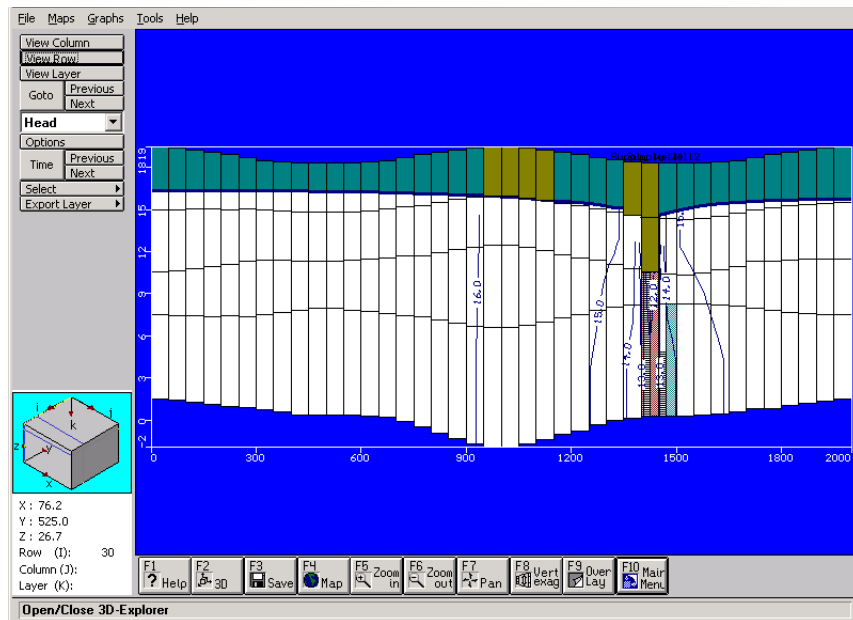
☞ **[X]** to close the **VMEngines** dialog.

Although the solution has not converged, we can examine the cross-sectional water table profile of the failed simulation to gain insight into the issue.

☞ **Output** from the top menu bar of the **Main Menu**

You will be transferred to the Visual MODFLOW Output section.

☞ **[View Row]** from side menu bar to view the cross-section with the the dry cells (desaturated condition). The display should look similar to the following figure (at row 30).



You may try to increase the number of outer iterations to 500. To do this

☞ **[F10 Main Menu]**

☞ **Run**

☞ **MODFLOW 2000 - Solver**

Type: 500 in the **MXITER** field

☞ **[OK]**

Once you finished with the settings, re-run the simulation.

You will see that the repeating pattern of head residual changes in the **VMEngines** window (i.e. oscillation) assures you that the problem can not be resolved by increasing the number of outer iterations. You could try smoothing out the hydraulic conductivity gradients, or redesigning the grid, or using another solver, or adjusting the re-wetting parameters. However, with high pumping rates, the problem of dry cells often cannot be avoided. In such a situation, we need to look for another solution.

Module 2: Running with MODFLOW-SURFACT

Why MODFLOW-SURFACT?

Using the MODFLOW-2000 Engine, a multi-layer well is represented as a group of single layer wells, and fails to take into account the inter-connection between various layers provided by the well. One of the most significant problems related to this approach is that well grid cells are essentially “shut off” when the water table drops below the bottom of the grid cell (i.e. when the grid cell becomes dry). This reduces the total pumping rate of the well (as the rate is distributed between all the screened cells initially), and may cause the water table to “rebound” and re-activate the dry well grid cell. This type of on-again-off-again behavior for the pumping well(s) causes the solution to oscillate, and may prevent the model from converging to a solution. In the event the model does converge to a solution, the model results may be misleading if one or more pumping wells have lower than expected total pumping rates.



This issue can be addressed by selecting the MODFLOW-SURFACT Engine for Flow. In contrast to the standard MODFLOW Engines, MODFLOW-SURFACT is able to dynamically redistribute pumping rates to the remaining active grid cells if one or more cells in the screened interval goes dry, thereby more accurately simulating the real-world effects of partial overpumping of a well screened over multiple layers.

In view of the serious difficulties encountered with the previous increased pumping rate simulation, an approach is required that allows free movement of the water table in the unconfined layers without any kind of forced convergence. The MODFLOW-SURFACT Flow Engine is capable of modeling unsaturated moisture, and couple the surface-water and groundwater flow regimes. It utilizes special numerical methods and powerful solvers to avoid the solution convergence problems caused by dry cells. A brief description of the MODFLOW-SURFACT capabilities is provided in Appendix-C of the Visual MODFLOW User’s Manual.

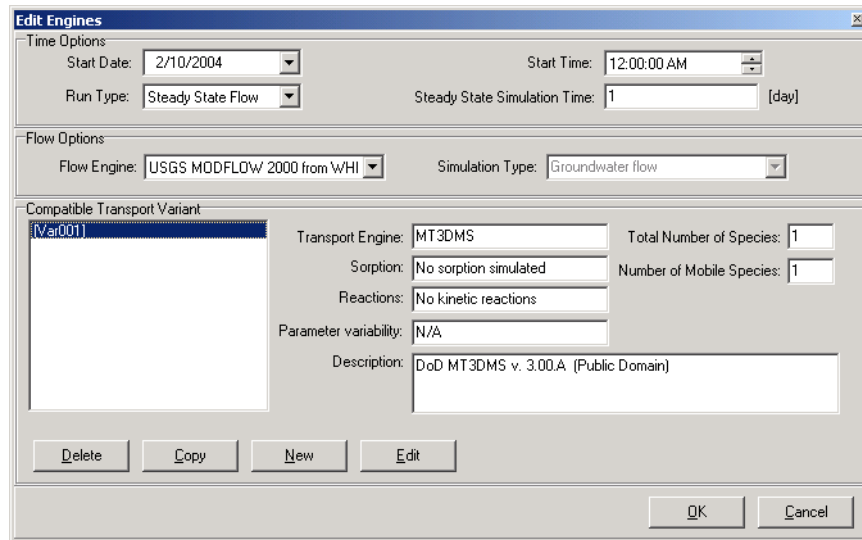
Module 2 will guide you through the selection of the MODFLOW-SURFACT Flow Engine, and show you how a solution for a model with dry cell problems can be obtained.

MODFLOW-SURFACT Run Options

In this section, you will select MODFLOW-SURFACT as the Flow Numeric Engine, and re-run your model.

-  **[Main Menu]** located on the bottom toolbar
-  **Setup/Edit Engines** from the top menu bar

The following **Edit Engines** dialogue will appear.



Edit Engines

Time Options
 Start Date: 2/10/2004 Start Time: 12:00:00 AM
 Run Type: Steady State Flow Steady State Simulation Time: 1 [day]

Flow Options
 Flow Engine: USGS MODFLOW 2000 from WHI Simulation Type: Groundwater flow

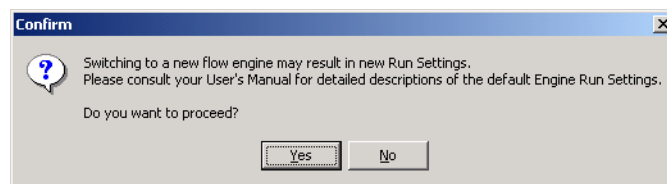
Compatible Transport Variant
 [Var001]

Transport Engine: MT3DMS Total Number of Species: 1
 Sorption: No sorption simulated Number of Mobile Species: 1
 Reactions: No kinetic reactions
 Parameter variability: N/A
 Description: DoD MT3DMS v. 3.00.A (Public Domain)

Delete Copy New Edit

OK Cancel

Select **MODFLOW-SURFACT** from **HGL** from the **Flow Engine** combo box
 The following message will appear:



Confirm

Switching to a new flow engine may result in new Run Settings.
 Please consult your User's Manual for detailed descriptions of the default Engine Run Settings.

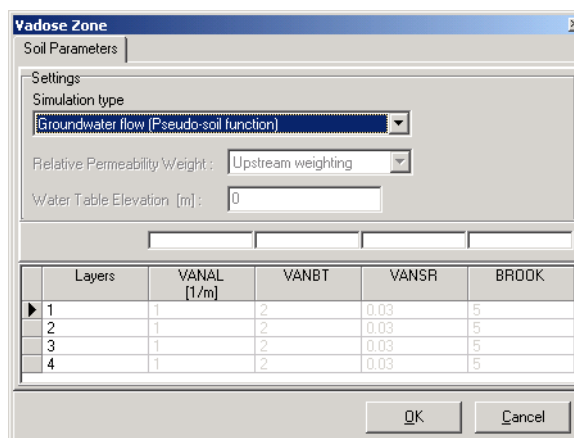
Do you want to proceed?

Yes No

- ☞ [Yes] to close the message window
- ☞ [OK] to close the **Edit Engines** dialogue
- ☞ **Input** from the top menu bar
- ☞ **Properties** from the top menu bar, and then **Vadose Zone**

NOTE: The **Vadose Zone** menu is only available when MODFLOW-SURFACT is the selected Flow Engine.

The **Vadose Zone** window will open, as shown below:



Vadose Zone

Soil Parameters

Settings
 Simulation type: Groundwater flow (Pseudo-soil function)
 Relative Permeability Weight: Upstream weighting
 Water Table Elevation [m]: 0

	Layers	VANAL [1/m]	VANBT	VANSR	BROOK
▶	1	1	2	0.03	5
	2	1	2	0.03	5
	3	1	2	0.03	5
	4	1	2	0.03	5

OK Cancel

From this window you may select different simulation types, as listed below, and customize hydraulic properties of the porous media and phase constants:

- Groundwater flow (Pseudo-soil function)
- Groundwater flow (van Genuchten)
- Groundwater flow (Brooke-Corey)
- Soil Vapor flow (van Genuchten)
- Soil Vapor flow (Brooke-Corey)

In this tutorial, the **Groundwater flow (Pseudo-soil function)** simulation type will be used. If this option is not already selected, click the pull-down menu and select it from the list. It simulates 3-D variably saturated flow, and can easily handle unconfined saturated-unsaturated moisture movement.

☞ **[OK]** to close the **Vadose Zone** window

☞ **[F10 Main Menu]** located on the bottom toolbar

☞ **[Run]** from the **Main Menu** options

You will be transferred to the Visual MODFLOW **Run** section.

Prior to running the model, in the **Run** section, you could customize the default run-time settings for MODFLOW-SURFACT including:

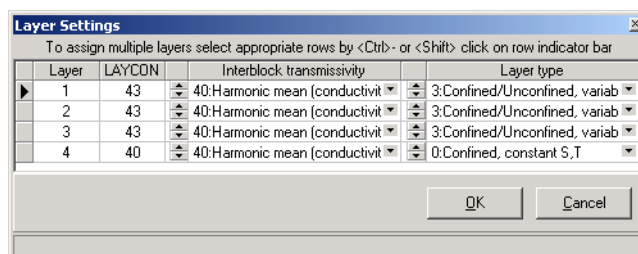
Time-steps for each stress period. This option is activated only when transient flow is simulated. MODFLOW-SURFACT includes “adaptive-time stepping” schemes with automatic generation and control of time steps to efficiently perform transient simulations.

Initial Heads provide the reference elevations for the heads in steady state solution, and can reduce the required run time significantly.

Solver selection and settings. Note that **PCG4** is specially designed for MODFLOW-SURFACT. PCG4 is a simple, robust, and efficient solver, which requires less computer resources than the PCG2 solver in MODFLOW.

Under the **Recharge** settings, in addition to Recharge options for MODFLOW, MODFLOW-SURFACT allows you to simulate a Seepage Face Boundary Condition. In this tutorial, the “**Recharge is applied to the uppermost active layer**” option is selected.

Layers settings are used to set the **Interblock transmissivity** and **Layer type**. The two settings are combined to make up the LAYCON value which is used by the numeric engines. Note that in MODFLOW-SURFACT the variably saturated flow options are implemented with Value 40 and 43 for all layers in the model grid (as shown below)



Rewetting settings are used to specify the conditions under which Dry Cells will become Wet again.

Anisotropy dialogue allows you to set the horizontal anisotropy by layer.

Using the **Output Control** dialogue you can customize the parameters and times that will be printed into the .LST file and/or saved to the binary file.

List File Opt allows you to specify which information will be written to the listing file (.LST), as well as the format of this information.

☞ **[Run]** from the top menu bar

In the **Engines to Run** dialog, select MODFLOW-SURFACT.

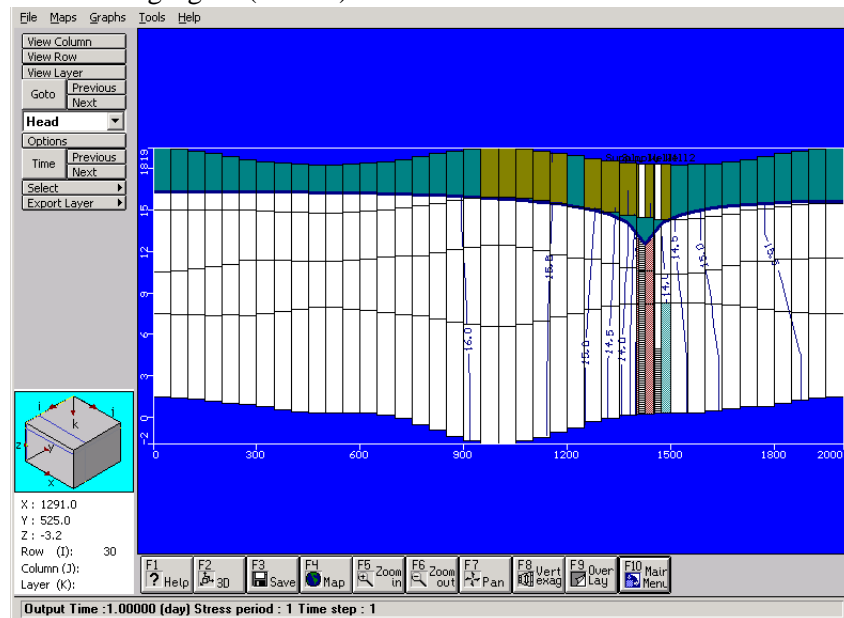
☞ ☒ **MODFLOW-SURFACT**

☞ **[Translate & Run]**

☞ **[Close]** to close the **VMEngines** dialog once the solution has converged.

☞ **Output** from the top menu bar of the **Main Menu**

You will be transferred to the Visual MODFLOW Output section. The display should look similar to the following figure (row 30).



As you can see, there are still dry cells at the top of the well, however the model converged.

Drawdown Cone Delineation, and Mass Balance Comparison

In this section you will modify the constant head boundary conditions and move the active pumping well to the center of the model. You will increase the pumping rate, and then run both Numeric Engines: MODFLOW-SURFACT and MODFLOW-2000. The input changes will create a steep hydraulic gradient (drawdown) around the well, and demonstrate how the pumping-induced dry cells are more realistically represented with MODFLOW-SURFACT than with MODFLOW-2000 (i.e. the shape of the drawdown cone obtained by MODFLOW-SURFACT will be much smoother than the shape obtained by MODFLOW-2000). Additionally, you will compare the Mass Balance results from the MODFLOW-2000 and MODFLOW-SURFACT runs.

☞ **[View Layer]** on the side toolbar, then move your cursor onto the model region, and click on Layer 1 to return to a Plan View.

☞ **[Main Menu]** located on the bottom toolbar

☞ **Input** from the **Main Menu** options

Now you will move the active pumping well (Supply Well1) from its existing location to the center of the model grid.

☞ **Wells/Pumping Wells** from the top menu bar

To move the pumping well to the center of your model:

☞ **[Move Well]**

Move the cursor to the top left pumping well and left-click to select the well, then move the cursor to the center of the model and left-click to move the pumping well to the new location.

☞ **[Edit Well]** from the Side Menu bar

Click on the well at it's new location, and an **Edit Well** window will appear (shown below). Enter the following information in the top row of the well table (Supply Well1):

X: 975 ⇔

Y: 1020

To modify the **Screened Intervals**, click in the column labelled **Screen Top** and enter the following values:

Screen Top (m):14.0 ⇔

Screen Bottom (m):1.29

In the **Pumping Schedule** frame, left-click inside the text box under the column labelled **Rate** and enter the following information:

Rate (m³/day): -3000

☞ **[OK]** to accept this well information

Next you will modify the **Constant Head** boundary conditions assigned along the north boundary.

Use the overlay picklist on the left-hand toolbar to switch from the **Pump Wells** to the **Const. Head** overlay (scroll through the list to find **Const. Head**).

☞ **[Yes]** to save your changes

☞ **[Edit>] Group** from the left hand toolbar. A **Constant-Head - [Edit Group]** window will appear.

☞ The brown colored cells at the top of the model and they will be highlighted in pink

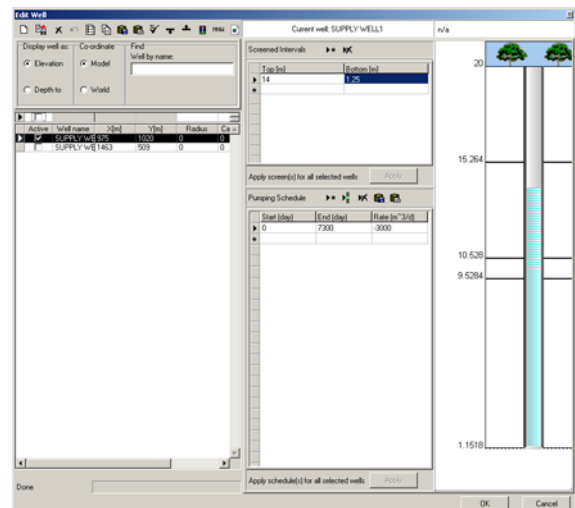
Change the head values by clicking in the **Start Time Head** column, then editing the "\$SHEAD" text that appears above the column heading. Repeat for the "\$EHEAD" text:

Start Time Head (m): 18 ⇔

Stop Time Head (m): 18

☞ **[OK]** to accept these values

The pink line of grid cells will turn back to a brown color, indicating that the Constant Head boundary condition has been changed for these cells.



Simulation with MODFLOW-2000

You will first run MODFLOW-2000 to see the effect of the input changes:

- ☞ **[Main Menu]** located on the bottom toolbar
- ☞ **[Yes]** to save your changes
- ☞ **Setup/Edit Engines** from the top menu bar
- ☞ **MODFLOW-2000** from the **Flow Engine** combo box
- ☞ **[Yes]** in the message
- ☞ **[OK]**

To continue with the run options:

- ☞ **[Run]** from the **Main Menu** options

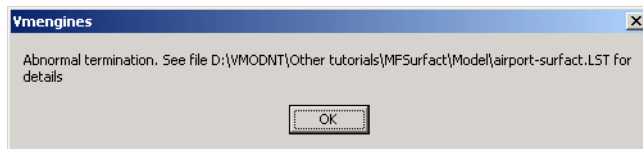
You will then be transferred to the run options screen:

- ☞ **Run** from the top menu bar

In the **Engines to Run** dialog, select the following options:

- ☞ ☒ **MODFLOW-2000**
- ☞ **[Translate & Run]**

After a few seconds the following message will appear:

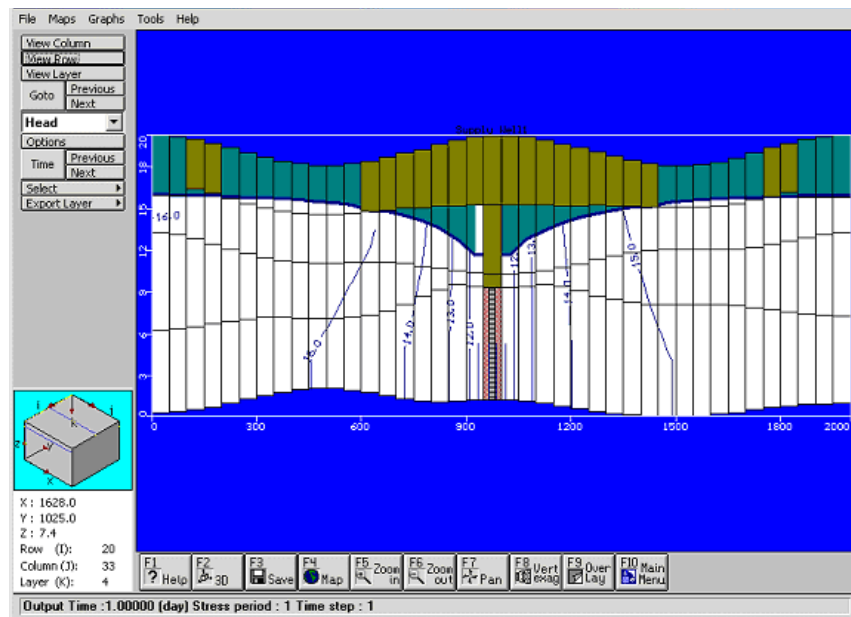


Although the solution has not converged, we can examine the cross-sectional water table profile of the failed simulation to gain insight into the issue.

- ☞ **[OK]** to close the dialog box, and **[Close]** the VMEngines window
- ☞ **[Output]** from the Top Menu bar of the **Main Menu**

You will be transferred to the Visual MODFLOW Output section. Visual MODFLOW will automatically load the available Output files for Head (.HDS).

Click **[View Row]**, and move your cursor onto the model region. Click to select a cross-section view, and the **Output** screen will similar to the screenshot below (row 20):

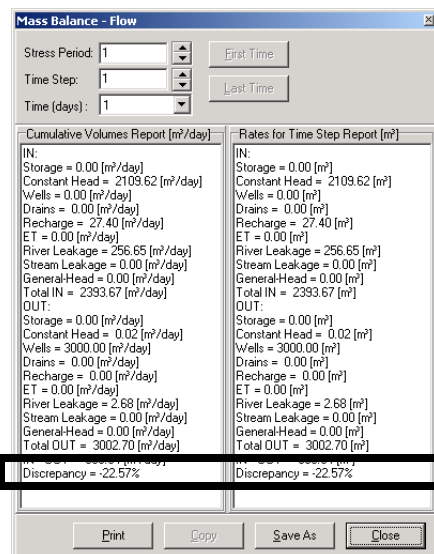


Note that the pumping induced dry cells (drawdown cone) surrounding the pumping well are limited to the shape of model grid, and therefore the distribution of the desaturated zone is not realistic.

Next we will take a look at the Mass Balance of this simulation:

- ☞ **Maps**, then select **Zone Budget**
- ☞ **[Mass Balance]** from the Left Menu bar

When we examine the Mass Balance of the MODFLOW-2000 simulation, we can see the obvious discrepancy between the inflow and outflow of the non-converged solution.



Simulation with MODFLOW-SURFACT

Now we will switch to the MODFLOW-SURFACT Flow Engine to see if we can obtain model convergence:

- ☞ **Main Menu** located on the bottom toolbar
- ☞ **Setup/Edit Engines** from the top menu bar
- ☞ Select **MODFLOW-SURFACT** from **HGL** from the **Flow Engine** combo box
- ☞ **[Yes]** in the message
- ☞ **[OK]** to close the **Edit Engines** window

To continue with the run options:

- ☞ **[Run]** from the **Main Menu** options

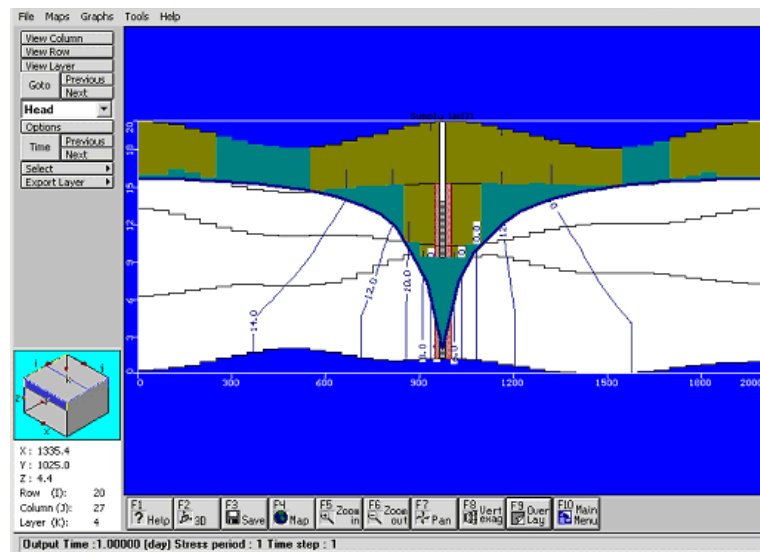
You will then be transferred to the run options screen:

- ☞ **Run** from the top menu bar

In the **Engines to Run** dialog, select the following options:

- ☞ ☒ **MODFLOW-SURFACT**
- ☞ **[Translate & Run]**

When your model has successfully converged, click **Output** menu and the **Output** screen will appear as shown below (row 20):

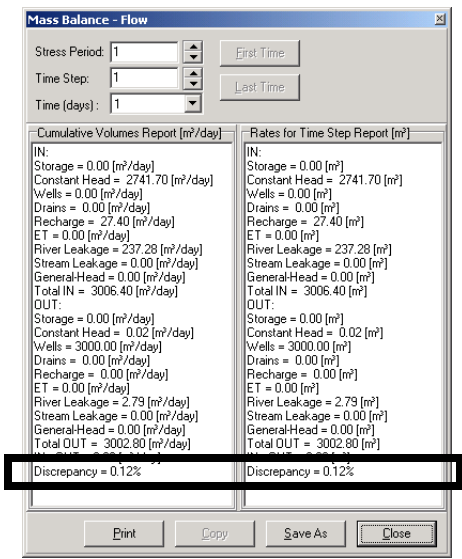


Note that the pumping induced desaturation surrounding the pumping well is represented by a smooth-shaped drawdown cone, which is more realistic than the one simulated by MODFLOW-2000.

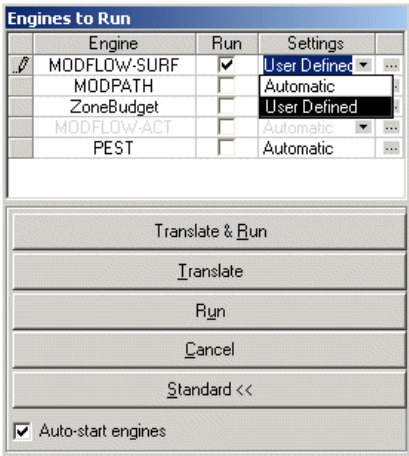
Note: You will notice in cross section that the cone of depression drops below the bottom of the well screen. This is because the general well package was used for this simulation. To achieve even more realistic output, select the **Fractured Linear Well (FLW4)** package in the

run settings. With this well package, the cone of depression will not drop below the bottom of the well screen.

When we examine the Mass Balance of the MODFLOW-SURFACT simulation (by clicking on **Maps - Zone Budget** from the Top Menu bar, then clicking on **[Mass Balance]** from the Left Menu bar), we can see that the percent discrepancy is much better, indicating we have a much more accurate solution. Since MODFLOW-SURFACT can automatically redistribute pumping rates when well cells go dry, a more accurate flow calculation can be made.

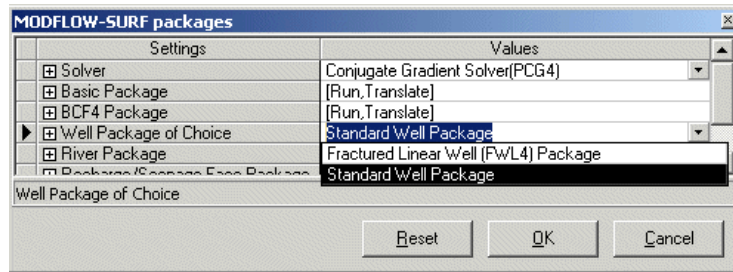


If time permits, you may also want to experiment with the well packages available through the **Engines to Run** window. Before running the model, you can select the **Advanced** options, and select the **User Defined Settings** option, as shown in the following screenshot.



By clicking on the  button, the **Packages** window will open , as shown in the following

screenshot, where you can switch between the standard well package, and the FWL4 package.



As described in the MODFLOW-SURFACT User's Manual (Chapter 3), the FWL4 package was designed to overcome several problems associated with the original WEL1 package. One important feature added to the FWL4 package is the ability to adjust total well withdrawal when the water level in the well has reached the well bottom. In situations where a partially penetrating well is being pumped beyond its capacity, the WEL1 package incorrectly continues its calculations and allows head values to drop below the well-bottom elevation. In other situations, the WEL1 package can cause the model to become unstable by cyclically drying and wetting the pumping cells between iterations.

Please **NOTE** that the FWL4 package will only function with 1 pumping well in the model. If you choose to experiment with this package, you will need to delete the second (inactive) pumping well before running the simulation.

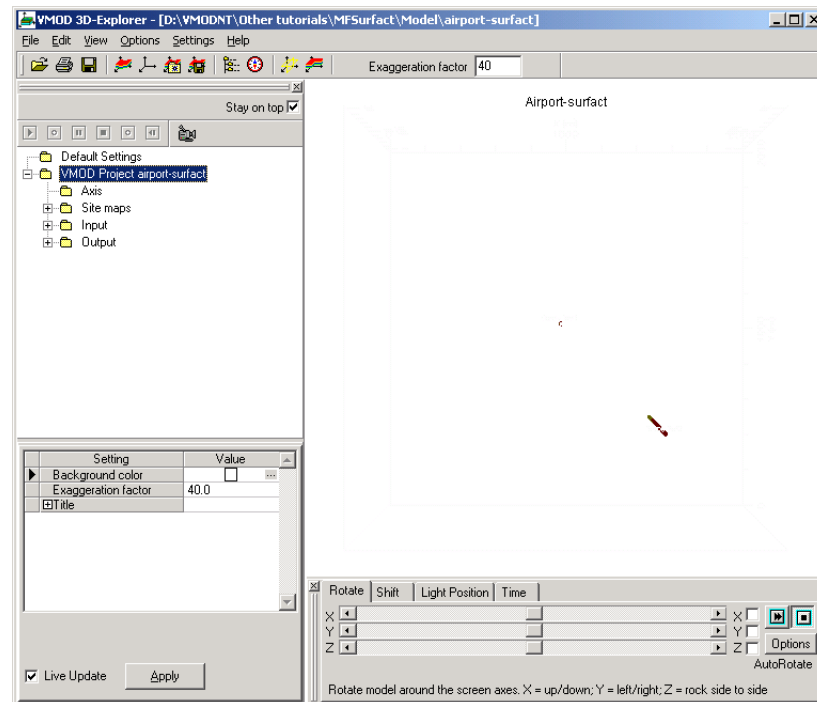
To continue with the rest of the tutorial, please see the following section describing the use of the Visual MODFLOW 3D Explorer.

Visualizing in 3D

Now that you have examined the model in various 2D views, you can visualize it in 3D. To do so,

☞ **[F2 3D]** button on the bottom toolbar

The **3D Explorer** window will load as shown below:

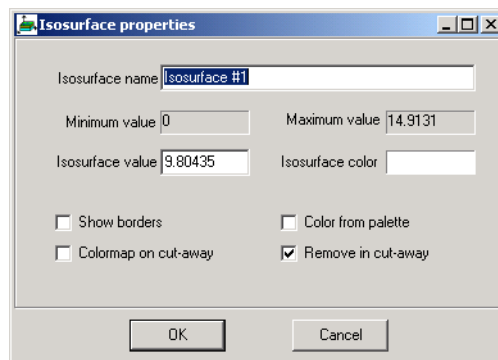


To display the depression cone

➡ **[+]** beside **Output**

➡ Right-click on **Drawdown** and select **Create Isosurface**

The following dialogue will load:



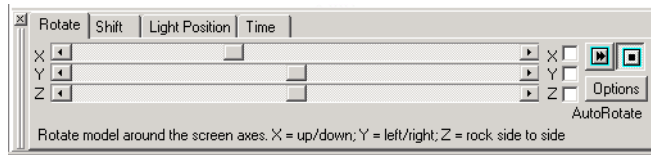
➡ ☒ **Show Borders**

➡ ☒ **Color from Palette**

type: 0 for the **Isosurface value**

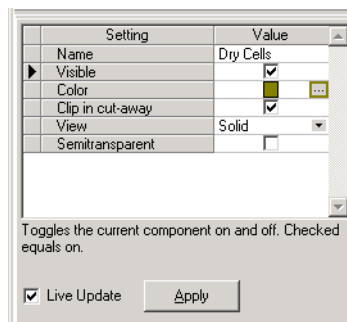
➡ **[OK]**

Use the Navigation Tools at the bottom of the model to position the grid so that you can clearly see the depression cone:



You can also display the dry cells. To do so:

- ☞ **[+]** beside **Heads**
- ☞ **Dry Cells**
- ☞ ☒ **Visible** in the Properties frame



Feel free to experiment with other features of the **3D Explorer**.

Summary

In this tutorial we have shown that model convergence difficulties arise when attempting to simulate the hydrogeological environment using the standard MODFLOW code. The steep hydraulic gradients surrounding the pumping well posed problems within the unsaturated zone of the model. The pseudo-soil function of MODFLOW-SURFACT was chosen to account for the saturated and unsaturated processes within the model, as it avoids the wet/dry non-linear iterations of standard MODFLOW. The main benefit of MODFLOW-SURFACT is that the user is able to focus on their model calibration, rather than model stability.

The major features of MODFLOW-SURFACT when coupled with Visual MODFLOW include:

- Extending the capability of Visual MODFLOW to handle Vadose Zone and Vapor flow simulations
- Greater stability and faster model convergence with complex solutions
- Accurate handling of pumping wells screened across multiple layers

These features make MODFLOW-SURFACT an excellent addition to the Visual MODFLOW modeling package.

